

**REMARKS**

Applicants are amending their claims in order to further clarify the definition of various aspects of the present invention. Specifically, Applicants have amended claim 22 to delete the expression “if any” from lines 3 and 5 thereof. Moreover, Applicants have amended claim 1 to recite a circuit connecting material “having a property that the material can electrically connect a first circuit member in which first circuit electrodes are located on the main surface of a first circuit board, and a second circuit member in which second circuit electrodes are located on the main surface of a second circuit board. Note, for example, paragraphs [0014] and [0015] on pages 7 and 8 of Applicants’ specification.

Initially, it is respectfully requested that the present amendments be entered, notwithstanding the Finality of the Office Action mailed December 16, 2009. In this regard, it is respectfully submitted that the present amendments do not raise any issue of new matter, noting portions of Applicants’ specification referred to in the foregoing, and previously considered claim 19; and noting previous recitations in claim 1, and claim 19 previously considered by the Examiner (reciting that the first and second circuit electrodes are “electrically connected” via the conductive particles) as well as arguments made in the Amendment filed August 17, 2009, it is respectfully submitted that the present amendments do not raise any new issues. By further clarifying the presently claimed subject matter, it is respectfully submitted that the present amendments materially limit issues remaining in connection with the above-identified application; and, at the very least, present the claims in better form for appeal. Moreover, noting contentions by the Examiner on page 3 of the Office Action mailed December 16, 2009, it is respectfully submitted that the present amendments are timely.

Furthermore, Applicants are submitting herewith a Declaration Under 37 CFR 1.132 of M. Arifuku, one of the named inventors in the above-identified application. This Declaration provides, in Declaration form, the data previously submitted with the Amendment filed August 17, 2009. Noting especially comments by the Examiner on page 2 of the Office Action mailed December 16, 2009, it is respectfully submitted that present submission of this Declaration is timely; and that this Declaration should be entered in the above-identified application, notwithstanding the Finality of the Office Action mailed December 16, 2009.

Applicants respectfully submit that all of the claims presented for consideration by the Examiner patentably distinguish over the teachings of the references applied by the Examiner in rejecting claims in the Office Action mailed December 16, 2009, that is, the teachings of U.S. Patent No. 6,338,195 to Tsukagoshi, et al., and the Japanese Patent Documents to Suga, et al., No. 2001-189171, to Suga, et al., No. 2001-283637, and to Kubota, No. 2000-208178, under the provisions of 35 USC 102 and 35 USC 103.

It is respectfully submitted that these references as applied by the Examiner would have neither disclosed nor would have suggested such a circuit connecting material as in the present claims, having a property that it can electrically connect the recited circuit members, with the recited insulating layer adjacent a circuit electrode of at least one of the circuit members, the insulating layer being thicker than such circuit electrode, including, inter alia, wherein the material includes conductive particles which have a hardness of 4.4413-6.865 GPa, and wherein the material exhibits a storage elastic modulus of 0.5-3 GPa at 40°C and a mean coefficient of thermal expansion of 30-200 ppm/°C at from 25°-100°C. See claim 1.

It is emphasized that, as will be discussed in more detail infra, such circuit connecting material can be used to electrically connect circuit members having first and second circuit electrodes located on surfaces of respective circuit boards having insulating layers of silicon dioxide or silicon nitride adjacent the circuit electrodes, with at least some of the insulating layers being formed such that the insulating layers are thicker than the circuit electrodes.

It is respectfully submitted that through use of the material having conductive particles, (1) with the conductive particles having a hardness of 4.4413-6.865 GPa, and the material (2) having a mean coefficient of thermal expansion of 30-200 ppm/°C at from 25°-100°C and (3) a storage elastic modulus of 0.5 to 3 GPa at 40°C, unexpectedly better results in reduced connection resistance between the electrodes connected, and improved bonding strength, are achieved.

In connection therewith, attention is respectfully directed to the enclosed Declaration Under 37 CFR 1.132 of M. Arifuku. This Declaration includes Additional Examples 1 and 2 within the scope of the present claims, Additional Reference Example 1 outside the scope of the present claims, and Additional Comparative Examples 1 and 2, also outside the scope of the present claims. Note Item 6 of this enclosed Declaration. The Additional Reference Example 1 falls outside the scope of the present claims, in using Conductive Particles No. 18, having a hardness outside the scope of the present claims. Additional Comparative Example 1 fell outside the scope of the present claims, in having a storage elastic modulus at 40°C outside the scope of the present claims; and Additional Comparative Example 2 fell outside the scope of the present claims, in having a mean coefficient of thermal expansion higher than 200 ppm/°C, i.e., greater than the maximum set forth in the present claims.

In connection with the enclosed Declaration, note the bonding strength, in Item 8 of the enclosed Declaration; and, in particular, the results in Table I and discussion in connection with Additional Comparative Example 1 in Item 9 of this Declaration; i.e., that the bonding strength could not be measured because the bonding agent had peeled away, because the storage elastic modulus at 40°C (4.3 GPa) exceeded 3 GPa and internal stress increased.

Note also Item 10 and Table II of this Declaration, and discussions in connection with the results shown in this Table II in Items 11 and 12; i.e., in Additional Reference Example 1, the connection resistance was higher than that of the Additional Examples 1 and 2 because the hardness of Conductive Particles No. 18 was lower than 4.4413 GPa; and that in Additional Comparative Example 2, the connection resistances were higher than that of the Additional Examples 1 and 2, because the mean coefficient of thermal expansion was higher than 200 ppm/°C.

Note also Table III in Item 14 of this Declaration; and the discussion of results therein in Items 15 and 16 of the Declaration; that is, that in Additional Reference Example 1, the connection resistances were higher than that of the Additional Examples 1 and 2, because hardness of Conductive Particles No. 18 was lower than 4.4413 GPa, and that in Additional Comparative Example 2, the connection resistances were higher than that of the Additional Examples 1 and 2, because the mean coefficient of thermal expansion was higher than 200 ppm/°C.

Note also Item 17 of this Declaration, stating that through use of the circuit connecting material of the present invention, it is possible to achieve a sufficient reduction in the connection resistance and a sufficient bonding strength, and in view of unexpectedly better results shown in Additional Examples 1 and 2, these effects are unexpected from the cited references.

It is respectfully submitted that from this evidence in the enclosed Declaration alone, Applicants have shown unexpectedly better results achieved where the circuit connecting material contains conductive particles having, inter alia, a hardness of 4.4413 to 6.865 GPa, and where the circuit connecting material exhibits, when cured, a storage elastic modulus of 0.5-3 GPa at 40°C, and a mean coefficient of thermal expansion of 30-200 ppm/°C at from 25 -100°C, providing a basis for a conclusion of unobviousness of the presently claimed subject matter, even were the teachings of the applied references to establish a prima facie case of obviousness (as will be shown in the following, it is respectfully submitted that the teachings of these references would not have established such a prima facie case).

Further supporting the evidence in the Declaration, attention is respectfully directed to the evidence in Applicants' specification. In particular, attention is respectfully directed to the results of Examples as set forth in Table 3 on page 58 of Applicants' specification, and the discussion in connection therewith in paragraphs [0136]-[0138] on pages 58 and 59 of Applicants' specification. In connection with these Examples, note description of the Examples on pages 50-54 of Applicants' specification, and description of the hardness of the conductive particles in Tables 1 and 2 on page 50 of Applicants' specification. Note particularly the discussion in paragraph [0138] on page 59 of Applicants' specification, that where the conductive particles used were too hard, sufficient flattening of the conductive particles cannot be obtained, and there was a rise in the connection resistance following the high-temperature, high-humidity treatment. It is respectfully submitted that this evidence in Applicants' specification must be considered in determining patentability of the presently claimed subject matter (see In re DeBlauwe, 222 USPQ 191 (CAFC 1984)), and further supports a conclusion of

unobviousness of the presently claimed subject matter, based upon establishing unexpectedly better results achieved by the present invention.

Furthermore, it is respectfully submitted that these references would have neither disclosed nor would have suggested such circuit connecting material as in the present claims, having conductive particles with a hardness, the material having a storage elastic modulus and mean coefficient of thermal expansion, as discussed previously in connection with claim 1, and, additionally, wherein the insulating layers having the differential thickness are located adjacent both the first and second circuit electrodes (note claim 20); and/or structure of the conductive particles, and material thereof, as in claims 2 and 3; and/or material of the bonding agent composition of the circuit connecting material, as in claims 4 and 5; and/or glass transition temperature of the circuit connecting material, as in claim 6, and as more particularly defined in claim 24; and/or further definition of the storage elastic modulus as in claim 25.

Moreover, it is respectfully submitted that the teachings of these applied references would have neither disclosed nor would have suggested such circuit connecting material as in the present claims, having features as discussed in connection with claim 1, and, additionally, wherein the circuit connecting material further contains a film forming material (see claim 7), in particular wherein such film forming material is a phenoxy resin (see claim 8); and/or the film-form circuit connecting material formed by forming the circuit connecting material according to claim 1 into the shape of a film (see claim 9).

Additionally, it is respectfully submitted that these references as applied by the Examiner would have neither disclosed nor would have suggested such a method for manufacturing a circuit member connecting structure which includes first and second circuit members respectively having first and second circuit members on

main surfaces thereof, the first and second circuit members respectively having first and second circuit electrodes, and wherein insulating layers of silicon dioxide or silicon nitride are located adjacent to at least one of the first circuit electrodes and the second circuit electrodes and at least some of the insulating layers being formed so that these layers are thicker than the circuit electrodes, with the film-form circuit connecting material according to claim 9 (which has the conductive particles with hardness as in claim 1, and the material has the storage elastic modulus and mean coefficient of thermal expansion of the material as in claim 1) being interposed between main surfaces of the first and second circuit boards and curing the circuit connecting material by application of heat and pressure so that the first and second circuit electrodes are electrically connected via conductive particles of the film-form circuit connecting material. See claim 19.

Furthermore, it is respectfully submitted that the teachings of these applied references would have neither disclosed nor would have suggested such method as in the present claims, having features as discussed previously in connection with claim 19, and, additionally, wherein the insulating layers having the greater thickness are located adjacent to both the first and second circuit electrodes (see claim 21); and/or difference in thickness between the insulating layer and adjacent first and second circuit electrodes, as in claim 22; and/or thickness of the film-form circuit connecting material as in claim 23.

The invention as being considered on the merits in the above-identified application is directed to a circuit connecting material, film-form circuit connecting material utilizing such circuit connecting material, and a method of manufacturing a circuit member connecting structure utilizing such film-form circuit connecting material.

Circuit member connecting structures used for the mutual connection of circuit members such as liquid crystal displays, tape carrier packages, flexible printed circuits, and printed wiring boards, among other uses, have been known in the past. Circuit connecting materials in which conductive particles are dispersed in a bonding agent have been proposed for the connection of circuit members, as described in paragraph [0002] on page 1 of Applicants' specification.

However, as circuits have been formed with progressively higher densities, so that spacing between circuit electrodes and the width of circuit electrodes have become narrow, it has become difficult to ensure high insulating properties between adjacent circuit electrodes on a surface, and it has been considered necessary to form an insulating layer comprising, e.g., silicon dioxide or silicon nitride between the adjacent circuit electrodes.

In providing structure having such insulating layers of silicon dioxide or silicon nitride, portions of the insulating layer ride over the edges of the circuit electrodes; and, specifically, as described in the sentence bridging pages 2 and 3 of Applicants' specification, in connection with Fig. 7 of Applicants' original disclosure, portions of the insulating layers 134 are formed with a greater thickness than the circuit electrodes 133 on the basis of the surface 132a of the circuit board 132. Various problems arise in connection with such structure. For example, connection resistance between the facing circuit electrodes is large, and long-term reliability of the electrical characteristics is insufficient.

Against this background, Applicants provide a circuit connecting material that can sufficiently reduce connection resistance between facing circuit electrodes, and that is superior in terms of long-term reliability of electrical characteristics. As a result of diligent research by the present inventors, the present inventors have found



that hardness of the conductive particles is an issue in connection with the circuit connecting material. Specifically, as described in paragraph [0008] bridging pages 4 and 5 of Applicants' specification, the present inventors discovered that if the hardness of the conductive particles is excessively large, the conductive particles become caught between the insulating films that ride over the edges of the circuit electrodes, so that the conductive particles do not make sufficient contact with both of the facing circuit electrodes; and that, as a result of this, the connection resistance between the facing circuit electrodes is increased. See, e.g., Fig. 7 of Applicants' disclosure.

Having discovered the source of this problem, the present inventors discovered that by utilizing a bonding agent composition and conductive particles as in the present claims, the conductive particles having a mean particle size and hardness as in the present claims, with the material, after curing, exhibiting a storage elastic modulus and mean coefficient of thermal expansion as in the present claims, objectives according to the present invention are achieved; and, in particular, a circuit connection can be achieved having reduced connection resistance and long-term reliability of the electrical characteristics. As described in paragraph [0011] on page 6 of Applicants' specification, even if conductive particles become caught between the insulating layers that face each other, with use of conductive particles having a hardness as in the present claims the conductive particles are appropriately flattened so that the distance between the facing circuit electrodes can be sufficiently reduced. See, e.g., Figs. 1 and 2 of Applicants' disclosure. Moreover, as the circuit members are firmly connected by the curing treatment of the circuit connecting material, so that variation in distance between the first and second circuit electrodes

over time can be sufficiently reduced, superior long-term reliability of electrical characteristics is achieved.

In particular, as described in paragraphs [0041] and [0042] on pages 17 and 18 of Applicants' specification, and as continued in paragraph [0043] thereof, by incorporating conductive particles having a hardness of a maximum of 6.865 GPa, the conductive particles can be sufficiently flattened so as to avoid increase in electrical resistance.

Furthermore, by utilizing the material having storage elastic modulus and mean coefficient of thermal expansion as in the present claims, an increase in connection resistance in the connecting parts as a result of internal stress, and peeling away of the bonding agent, can be avoided. Note also paragraph [0065] on page 29, and paragraph [0069] bridging pages 30 and 31, of Applicants' specification. See the results in the Tables I-III of the enclosed Declaration, and the discussion thereof in Items 9, 11, 12, 15 and 16 of this Declaration.

Furthermore, by utilizing a circuit connecting material having a glass transition temperature as in various of the present claims, a reduction in bonding strength at high temperature and a rise in connection resistance can be avoided, and internal and interfacial stresses in the circuit connecting member, which can cause cracking to occur and a reduction in bonding strength, can be avoided.

No. 2001-189171 discloses an anisotropic conductive connection material and use thereof, such connection material being adhered mechanically without damaging a passivation film. This patent document discloses a semiconductor device having electrodes 4 at a lower position than a passivation film 5, which generally is made of a resin, connected to a circuit board by connection material 6 having adhesive components 7 and conductive particles 8. The particles, having a nucleus covered

with a metal layer, are used as conductive particles, and are of a diameter  $d$  of not less than 1.5 times the height difference between the passivation film 5 and the electrodes 4, and not more than 0.5 times the interval between the electrodes. Note, in particular, paragraphs [0007], [0008] and [0015]-[0020] of this patent document. This patent document discloses that the hardness (K value) of the conductive particles is 500-100,000 N/mm<sup>2</sup>, preferably 1,000-8,000 N/mm<sup>2</sup>. See paragraph [0020] of this patent document.

This patent document focuses on the hardness of the conductive particles to avoid possible damage to the passivation film. See paragraph [0034] of this patent document.

It is respectfully submitted that this reference does not disclose, nor would have suggested, the material according to the present invention, having the insulating layer of silicon dioxide or silicon nitride (the reference disclosing a resin passivation layer), or the hardness of the conductive particles, or storage elastic modulus or mean coefficient of thermal expansion of the circuit connecting material (after curing), and unexpectedly better results achieved thereby; and/or other advantages of the present invention as discussed in the foregoing, and advantages achieved thereby.

It is noted that the Examiner indicates that No. 2001-189171 "fails to teach the instant claimed hardness of the conductive particles or their particle sizes and the specific insulator layers per the claims-1 and 19". In addition, it is respectfully submitted that this reference does not disclose, nor would have suggested, advantages achieved by utilizing a hardness as in the present claims, and also would have neither disclosed nor would have suggested the storage elastic modulus

and mean coefficient of thermal expansion of the material after curing, and unexpected advantages thereof.

Emphasizing that No. 2001-189171 focuses on a different effect for the conductive particles (that is, avoiding damage of the passivation film), rather than avoiding increased connection resistance as in the present invention, it is respectfully submitted that the disclosure of this patent document would have taught away from features of the present invention, including the specific range hardness of the conductive particles, as in the present claims, and advantages thereof.

It is respectfully submitted that the additional teachings of the secondary applied references would not have rectified the deficiencies of No. 2001-189171, such that the presently claimed invention would have been obvious to one of ordinary skill in the art.

Tsukagoshi, et al. discloses a connection sheet for firmly bonding an electronic component such as a semiconductor chip to a circuit board to achieve electrical connection between electrodes of the two components, the connection sheet including a first adhesive layer made of a first adhesive having an electrical insulating property, a second adhesive layer placed over the first adhesive layer, the second adhesive layer containing a second adhesive having an electrical insulating property and an electrically conductive material, and the second adhesive having a viscosity equal to or lower than that of the first adhesive when the first and second adhesives are in a molten state. Note the paragraph bridging columns 2 and 3 of this patent. See also column 3, lines 4-14 of this patent document. Note also the connection structure described in column 4, lines 12-29 of this patent document. As for the conductive material, note column 8, lines 45-63 of this patent document; and note also column 9, lines 4-11, describing that the particle diameter of the conducting

particles should preferably be as small as 15  $\mu\text{m}$  or less, more preferably, in the range of 7-1  $\mu\text{m}$ . See also column 10, lines 20-23 of this patent document. Note also the embodiment shown in Fig. 8 and the description in connection therewith in column 13, lines 18-30, of Tsukagoshi, et al., showing a recessed electrode 16, with an unnecessary portion of the electrode (which is an Al pad) being covered with an insulating layer made of silica, silicon nitride, polyimide, etc.

No. 2001-283637 discloses an anisotropic conductive bonding material having conductive particles dispersed in a thermosetting resin, a 10% compression bonding modulus of elasticity (E) of the conductive particles and a vertical modulus of elasticity (E') of the protruded electrode of the electronic element being connected with the anisotropic conductive bonding material being satisfied with a relational expression,  $0.02 \leq E/E' \leq 0.5$ . This patent document is directed to the problem arising due to hardness of a nickel bump of a chip size package, with the conductive particle being crushed by the nickel bump, and the aforementioned technique for avoiding this problem being set forth in paragraph [0007] of this patent document. See also paragraph [0036] of this patent document, describing, in the Example thereof, use of gold-plated particles of spherical benzoguanamine resin, the particles having a 10% compressibility  $E = 4.7 \text{ GPa}$ .

Initially, it is emphasized that No. 2001-283637 is directed to structure with protruding electrodes. It is respectfully submitted that one of ordinary skill in the art concerned with in No. 2001-189171, having recessed electrodes, noting that the present invention also has recessed electrodes, would not have looked to the teachings of No. 2001-283637. Emphasizing that No. 2001-283637 is concerned with crushing of conductive particles by the nickel bump (protruding electrode), it is

respectfully submitted that the teachings of this reference are not relevant with respect to the presently claimed subject matter.

In any event, even assuming, arguendo, that the teachings of No. 2001-283637 were properly combinable with the teachings of the other applied references, including No. 2001-189171, such combined teachings would have neither disclosed nor would have suggested the presently claimed subject matter, including hardness of the particles (it being noted that No. 2001-283637 discloses a 10% compression bonding modulus of elasticity), or storage elastic modulus or mean coefficient of thermal expansion of the circuit connecting material, together with the hardness, or advantages achieved by combination of these features.

No. 2000-208178 discloses structure which satisfactorily keeps an insulating property of an anisotropic conductive film between adjacent first terminal electrodes, at low cost, by forming a groove between the first terminal electrodes. Specifically, this patent document discloses a strip anisotropic conductive film being arranged across a groove on a terminal electrode, with a terminal electrode of a liquid crystal panel being opposed and bonded to this terminal electrode (of a drive circuit substrate) through the anisotropic conductive film. This patent document discloses that, as a conductive particle included in the anisotropic conductive film, those having a diameter of 2-3  $\mu\text{m}$  or used. Note, in particular, paragraph [0009] this patent document.

Even assuming, arguendo, that the teachings of Tsukagoshi, et al., No. 2001-283637 and No. 2000-208178 were properly combinable with the teachings of No. 2001-189171, such combined teachings would have neither disclosed nor would have suggested the presently claimed material and method, including the specific range for the hardness of the conductive particles, or storage elastic modulus or

June 16, 2010

mean coefficient of thermal expansion of the circuit connecting material after curing, and unexpectedly better results achieved by the combination of these features in reduced resistance, and avoidance of peeling (that is, providing a sufficient bonding strength), as achieved according to the present invention.

In view of the foregoing comments and amendments, and, moreover, in view of the concurrently submitted Declaration Under 37 CFR 1.132, entry of this Declaration and of the present amendments, and reconsideration and allowance of all claims presently in the above-identified application, are respectfully requested.

To the extent necessary, Applicants hereby petition for an extension of time under 37 CFR 1.136. Kindly charge any shortage of fees due in connection with the filing of this paper, including any extension of time fees, to the Deposit Account of Antonelli, Terry, Stout & Kraus, LLP, Account No. 01-2135 (case 1303.45151X00), and please credit any overpayments to such Deposit Account.

Respectfully submitted,

**ANTONELLI, TERRY, STOUT & KRAUS, LLP**

By /William I. Solomon/  
William I. Solomon  
Registration No. 28,565

Enclosure: Declaration Under 37 CFR 1.132

WIS/ksh  
1300 N. 17<sup>th</sup> Street, Suite 1800  
Arlington, Virginia 22209  
Tel: 703-312-6600  
Fax: 703-312-6666